

REMARKS

Further and favorable reconsideration is respectfully requested in view of the foregoing amendments and following remarks.

Claim 1 has been amended to incorporate the limitations of claim 20, and to require that the bainite microstructure obtained after controlled cooling of the blank is 100% bainite. Claims 20 and 21 have been cancelled, without prejudice. New claims 22-24 have been added to more explicitly recite the cases where only one precipitation hardening mode, as recited in claim 1, is employed. No new matter has been added to the application by these amendments.

The objection to claim 21 as being a substantial duplicate of claim 1 is rendered moot, in view of the cancellation of claim 21.

The patentability of the present invention over the disclosures of the references relied upon by the Examiner in rejecting the claims will be apparent upon consideration of the following remarks.

The rejection of claims 1, 5, 8-10 and 19-21 under 35 U.S.C. § 103(a) as being unpatentable over Takada et al. (U.S. 5,660,648) in view of Nakamura et al. (U.S. 6,558,483) is respectfully traversed.

The Examiner takes the position that Takada et al. describe an analogous bainitic steel part processed in substantially the same manner as claimed by Applicants. The Examiner further states that Takada et al. teach using a steel alloy having constituents whose wt% ranges overlap those recited by the claims. The Examiner states that the overlap in alloy wt% ranges and temperature ranges establishes a prima facie case of obviousness because it would be obvious to one of ordinary skill in the art to select the claimed ranges from the broader disclosure since the prior art teaches similar high strength properties and the same utility.

The Examiner admits that the aging time (precipitation annealing) is not taught by the reference, but the Examiner asserts that this is not a patentable difference, since it would have been obvious to perform it for obtaining the desired strength and hardness, which are not new and unexpected results. The Examiner further asserts that the prior art teaches air cooling similar to the invention.

It is true that Takada et al. describe steels with a structure containing bainite, preferably at least 80% of bainite (see claim 9). However, Applicants' amended claims

require that the bainite microstructure obtained after controlled cooling of the blank is 100% bainite. The steels of Takada et al. are in a non-quenched and tempered state, with a tensile strength of 1000 MPa or more. The Ceq content is at least 0.82% and the temperature BS for the beginning of the bainitic transformation is at most 810K (= 537°C). (See column 1, lines 55-59 and column 2, lines 37-50 of Takada et al.)

Although there can be some overlapping in the ranges of several elements in the steel of Takada et al. and Applicants' recited steel, there are also significant differences, as discussed below.

Applicants' invention permits C and Ceq contents which are inferior to what Takada et al. require. For example, if the Ceq of the steel recited in Applicants' claim 1 is calculated with the lowest possible contents, i.e. C (0.06%), Si (0%), Mn (0.5%), Cr (0%) and V (0%), according to the formula of Takada et al., the Ceq = 0.15%. On the contrary, Ceq must be at least 0.82% in Takada et al.

The goal of Takada et al. is to simultaneously obtain a very high tensile strength (> 1000MPa) and a high toughness. A high hardness is also desired.

In Applicants' invention, a high tensile strength is also sought in some, but not all, cases. (See page 10, lines 3-8 of Applicants' specification.) Additionally, a high hardness is desired in Applicants' invention. However, high toughness is not required. The objective of Applicants' invention is a good fatigue behaviour and a good machinability. These requirements are either absent in Takada et al. (fatigue) or present only in a secondary manner (machinability). The elements which improve machinability (Pb, Bi, Te, Se), are not present in the examples or the claims of Takada et al.

In Takada et al., Si is systematically present at a high content (0.9-3%), while it can be totally absent from Applicants' invention.

V is systematically present in Takada et al., while it is only optional in Applicants' invention. Additionally, Applicants' invention includes a maximum content of 2% V, which is much more than the 0.5% maximum of Takada et al. A very high content of V (at least 0.5%, which is the maximum of Takada et al.) is the key feature of one of the embodiments of Applicants' invention. This demonstrates that the functions of V in both cases are not identical, or are at least not fulfilled with the same efficiency.

A precipitation hardening during aging is mentioned in Takada et al. (column 5, lines 35-44), but Takada et al. do not recognize any metallurgical interest in contents of V

higher than 0.5%. Also, Takada et al. do not recognize any interest in obtaining a precipitation hardening by the other methods considered in Applicants' invention.

Takada et al. have no particular requirement regarding Cu, which accordingly must remain at the level of usual impurities. In Applicants' invention, the Cu content can be as high as 3.5%, and is at least 0.5% if Cu is the only element by which a precipitation hardening is obtained. (See Applicants' claim 1, and new claim 22.)

Also, Takada et al. have no requirement regarding Ni, much less in connection with Al, the presence of which is always limited to 0.050%. Massive and joint presences of Ni and Al, which are tolerated or even required in Applicants' invention (see claim 1 and new claim 24), are not taught or suggested by Takada et al.

Takada et al. do not mention B, while in Applicants' invention, B is compulsory for improving quenchability of the steels. Therefore, the relation of B with Ti can not be taught or suggested by Takada et al., and neither can the required $Ti/N \geq 3.5$ ratio. In fact, most of the examples of Takada et al. have a Ti/N ratio which is far inferior to 3.5. (See examples 1-27, 30, 32, 43, 45, 47, 48.)

Another important reason for the presence of B is to help avoid the persistence of ferrite and residual austenite in the final microstructure, which in the invention must be 100% bainite (see amended claim 1). On the contrary, Takada et al. tolerate up to 20% of phases other than bainite in cases where high strength and toughness are required. If such features are not required, such higher contents of ferrite, pearlite, martensite and austenite are accepted. See tables 1 and 2, where many steels according to the invention of Takada et al. have high contents of phases other than bainite.

A comparison of the examples of the present application and an example based on the requirements of Takada et al. provide the following results, Ceq and BS being calculated according to the formulae of Takada et al.

Ex.1 Ceq = 0.44 % BS = 965 K

(inv.)

Ex.2 Ceq = 0.71 % BS = 844 K

(inv.)

Ex.3 Ceq = 0.37 % BS = 988 K

(inv.)

Ex.4 Ceq = 0.80 % BS = 810 K

(reference)

Takada et al. $C_{eq} \geq 0.82 \%$ BS ≤ 810 K

All three examples according to Applicants' invention are frankly out of the requirements of Takada et al. on C_{eq} and BS, while reference example 4 has a C_{eq} just under the requirement of Takada et al. and a BS at the upper limit of the requirements of Takada et al.

These results further demonstrate that the teachings of Takada et al. and Applicants' invention are distinct. The composition of Applicants' invention is not a mere selection made from the teachings of Takada et al., but instead is something quite different.

Additionally, no example of Takada et al. is in accordance with the invention, or even close to it. Only one, sample 23, respects $0.5 \leq V \leq 2 \%$, and no other respects any one of the three requirements of claim 1 concerning obtaining a sufficient precipitation hardening. However, sample 23 has no Al and no Ti, does not fulfil the condition $Ti \geq 3.5N$, contains no B, and contains no machinability increasing elements.

Note, also, that this sample 23 of Takada et al. is a reference sample, and the reader of Takada et al. would have no motivation to start from this sample and modify the composition, for any precise purpose, in particular for the purposes of Applicants' invention.

Furthermore, as discussed briefly above, Applicants' invention aims at (and the claims require) a fully bainite microstructure. (See claim 1 and the parts of the specification which refer to the microstructure: for example, page 4, line 25, page 6, lines 29-30, page 10, line 27, page 11, line 14 and page 12, lines 3-4). On the contrary, the reference example 4 has only a mainly bainite microstructure. So, the reference fails to teach a 100% bainite microstructure, which is essential for Applicants' invention.

Claim 1 of Takada et al. does not refer to a bainite microstructure, but rather to a bainitic microstructure, which is a structure which mainly contains bainite, but may contain relatively large amounts of other phases. Even in the preferred embodiments of the reference, the bainite content can be as low as 80% (see claim 9). This is yet another demonstration that the steels of Applicants' invention and the steels of Takada et al. are distinct.

The forging temperature of Takada et al. is at least 1270 K, that is at least 997°C. In the present application, the forging temperature must lie between 1100 and 1300°C, which is much more precise and often higher. A forging temperature in accordance with Takada et al. is not forcibly in accordance with the invention, as it can be higher or lower.

In Takada et al., the steel is simply allowed to cool in air after the forging step, without any further requirement. In Applicants' invention, controlling this cooling step is imperative, in that when the steel is between 600 and 300°C, its cooling speed must be $\leq 3^\circ\text{C/s}$. This specificity is not automatically obtained, and is essential for obtaining the 100% bainite structure required by Applicants' claimed invention.

In the present application, reference example 4 was simply cooled in still air, without any precision on the cooling speed between 600-300°C, and the resulting microstructure was not entirely bainitic. This confirms that the uncontrolled cooling in air, as taught by Takada et al., can lead to structures containing significant quantities of phases other than bainite. On the contrary, examples 1-3 according to Applicants' invention, for which the average cooling speed was precisely measured between 700-300°C (so including 600-300°C) as being 1°C/s , resulted in the required bainite structure.

Concerning the mechanical properties of steel, Takada et al. aim at obtaining a ratio tensile strength/yield-strength (R_e/R_m) as high as 0.80 (see table 3) after an aging at 830 K (537°C). Such a concern is not present in the invention, where the R_e/R_m ratio may be as low as 0.67 (see page 3, lines 25-29) or even less. In fact, the examples do not even speak of this ratio.

Also, the toughness is important to consider in Takada et al.: the UE value is cited in the tables, which expresses the toughness measured in a Charpy test with a U-notch on the sample. (See column 4, lines 22-23, 28, 41, 54 and 63-67, column 5, lines 35-36, 47, 51-52 and 61-62, and column 6, lines 49-50.) However, a high toughness is not required in Applicants' invention.

Further, in column 1, lines 18-24, Takada et al. insist on the importance of a high yield ratio coupled to a high toughness, obtained by adjusting the aging temperature at a possibly relatively low level (450-900 K, that is 170-627°C, 570, 830 K in the examples, that is 297°-557°C). In Applicants' invention, the optimal temperature of the precipitation annealing depends on the steel composition, particularly on the chosen way to obtain precipitation hardening, and is 450°C, 580°C and 520°C in the examples. An annealing at

300-450°C, in the reference example 4 of the application, failed to give a convenient increase of the mechanical properties.

Sample 23 of Takada et al., which can be considered the closest to Applicants' invention based on its composition (it contains 0.6% of V) has a tensile strength of 1075MPa after forging and cooling at an uncontrolled speed. After an aging at 570 K (297°C), so under what is required by claim 1 of the invention (500-600°C), the tensile strength remains at the same level (1076MPa). The aging of Takada et al. had no use concerning tensile strength. Its aim was only to increase the yield strength. This shows that the combination of process and composition features of claim 1 is necessary for obtaining the good results of the invention concerning tensile strength, and that the steels described in Takada et al. are quite different from the steels obtained by Applicants' invention.

Nakamura et al. is cited by the Examiner in combination with Takada et al. only because it teaches to add B to the steel, in order to improve its hardenability. However, the addition of B is in no way related to an addition of Ti, which is itself not linked with the presence of N. Actually, none of the examples of Nakamura et al. has $Ti/N \geq 3.5$, and none of the examples contain B.

Enclosed herewith is a figure (Document 1) which shows the influence of B and $Ti/N \geq 3.5$ on the steel properties, in the precise case of the invention. It can be seen that fulfilling simultaneously both these conditions help to "push" the ferritic field to the right part of the diagram time/temperature on which the different phases of the steel of the invention (or of a steel close to the invention) appear. The effect of pushing back this ferritic field is that during the cooling which follows forging, the steel is not likely to cross the ferritic field and goes directly from the austenitic field to the bainite field. That results in surely avoiding the presence of residual ferrite in the steel at the end of the thermal treatment, in particular if, according to the invention, it appears necessary to slow down the cooling between 600 and 300°C for making its rate $\leq 3^\circ\text{C/s}$. Document 1 will be discussed in more detail below.

For these reasons, the subject matter of claims 1, 5, 8-10 and 19 is clearly patentable over the cited combination of references.

The rejection of claims 1, 5, 8-10 and 19-21 under 35 U.S.C. § 103(a) as being unpatentable over JP '374 alone or in view of Nakamura et al. is respectfully traversed.

The Examiner takes the position that JP '374 teaches producing a bainitic steel by hot forging at 1050 to 1200°C, air cooling at 72C/min in the range of 800-500°C. The Examiner asserts that the overlap in alloy wt% range and temperature ranges establishes a prima facie case of obviousness because it would be obvious to one of ordinary skill in the art to select the claimed ranges from the broader disclosure, since the prior art teaches similar high strength properties and the same utility. The Examiner states that even though JP '374 do not teach Cu or Ni, they would be expected to be present as inevitable impurities in trace amounts. The Examiner further asserts that B is commonly added to steel to further enhance hardenability.

The following comments demonstrate that one of ordinary skill in the art would not achieve Applicants' invention from the teachings of the cited references.

Although the steel of JP '374 discusses bainitic ratio, and has a composition which can overlap Applicants' invention in some aspects, (such as V being sufficiently present for allowing the precipitation hardening during annealing to take place), the invention of JP '374 is distinct from Applicants' invention for the following reasons.

First, Ti is not required in JP '374. Although some of the examples contain Ti, usually it is not enough to fulfil Applicants' requirement of $Ti \geq 3.5 \text{ N}$.

Second, there is no B in JP '374, as admitted by the Examiner. As discussed above, regarding Takada et al., B is compulsory in Applicants' steel to help avoid the persistence of ferrite and residual austenite in the final microstructure, which in the invention must be 100% bainite (see amended claim 1). Additionally, as shown in the attached Document 1, and discussed above, the influence of B and $Ti/N \geq 3.5$ on the steel properties, help to "push" the ferritic field to the right part of the diagram, so that during the cooling which follows forging, the steel is not likely to cross the ferritic field and goes directly from the austenitic field to the bainite field. That results in surely avoiding the presence of residual ferrite in the steel at the end of the thermal treatment, in particular if, according to the invention, it appears necessary to slow down the cooling between 600 and 300°C for making its rate $\leq 3^\circ\text{C/s}$.

In Applicants' invention, both conditions $B = 5\text{-}50\text{ppm}$ and $Ti \geq 3.5 \text{ N}$ must be fulfilled, in order to ensure that bainite will be the only present phase after the controlled

cooling following forging. If not enough Ti is present while B is present, N will be partially combined with B for forming boron nitrides and/or carbonitrides, and not enough free B will be present for ensuring a displacement of the ferrite domain to the right of the diagram of Document 1.

JP '374 fail to recognize the need for B, and the need for $Ti/N \geq 3.5$. The absence of B makes a significant difference between the invention and JP '374. Further, this reiterates why JP'374 does not especially recommend a minimum Ti/N ratio, since Ti is not compulsory. Applicants' invention results in a purely bainite structure; while a merely "bainitic" structure (that is where bainite would be the main but not exclusive component) results from JP '374. The abstract of JP'374 refers to a bainitic ratio $\geq 70\%$. That means that JP '374 can tolerate a high proportion of other phases than bainite, contrary to Applicants' invention.

Third, the presence of $S \geq 0.005\%$ is not compulsory in JP '374.

Fourth, none of the examples of JP '374 have a composition according to Applicants' invention regarding every main element. R is the closest example, but it contains no Ti, no S and no machinability element.

Fifth, Mo is compulsory in JP '374, while it is only optional in Applicants' invention.

In JP '374, some of the samples of tables 3 and 4 have a % of bainite of 100% or close to it. However, each of these examples differ from Applicants' invention on several points. C, G and J have too much Mn and no Ti, and G has too much Pb. D has too much Mn and not enough Ti for obtaining $Ti \geq 3.5 N$. E has not enough Ti for obtaining $Ti \geq 3.5 N$, and too much Cr. M has too much Mn, and also too much Ti. Sample E of JP '374 contains Nb, which is not compulsory in Applicants' invention. This addition of Nb is the reason why sample E has a 100% bainite structure.

The effect of the excessive presence of Cr in sample E, as compared to Applicants' invention (1.54% instead of $\leq 1.2\%$) is to enhance the hardenability which can induce formation of martensite, which is not tolerated in the invention. That is one of the reasons why Cr is limited to 1.2% in Applicants' invention.

Nevertheless, in JP '374, the presence of Nb in sample E has the following effect: it extends the bainite field, and so has allowed the 100% bainite structure of sample E, in spite of the high content in Cr and the low content in Ti of sample E. The other

requirements of Applicants' invention concerning the composition (B, Ti, T \geq 3.5 N) and the cooling mode allow one to obtain a 100% bainite structure without compulsorily using Nb. On the contrary, a significant presence of this costly element is required in JP '374 for surely obtaining a sufficient proportion of bainite. Although it is noted that JP '374 do not require 100% bainite.

In JP '374, Nb also has another function, which is to help to obtain yield strengths Re (or Rp_{0.2}) and tensile strengths Rm as close as possible to each other, that is a high Re/Rm ratio. (See the tables of JP '374 where Rp_{0.2} is over 900 MPa.) Nb makes the metal grains thinner, which allows an increase in the yield strength without downgrading the tensile strength.

Applicants' invention differs from JP '374 in the following ways.

1. Obtaining a high Re/Rm ratio is not particularly desired in Applicants' invention.

2. Applicants aim to avoid the presence of ferrite, by a combination of a selected steel composition and precise requirements regarding the cooling speed between 600 and 300°C, that is within the temperature range where ferrite would possibly be formed.

3. In JP '374, the cooling speed is controlled only between 800 and 500°C, and avoiding the presence of ferrite is not essential at all, since up to 30% of the structure may be another phase than bainite, including ferrite.

Although some of the teachings of JP '374 overlap Applicants' invention, the teachings of JP '374, taken as a whole, do not render obvious Applicants' claimed method. Specifically, Applicants' invention aims for 100% bainite microstructure, which is achieved by a particular method and a particular steel composition. The combination of JP '374 with Nakamura et al. does not remedy the above discussed deficiencies of JP '374.

For these reasons, the subject matter of claims 1, 5, 8-10 and 19 is clearly patentable over the cited combination of references.

The rejection of claims 1, 5, 8-11 and 19-21 under 35 U.S.C. § 103(a) as being unpatentable over Hill et al. (RE 28,523) is respectfully traversed.

The Examiner takes the position that Hill et al. disclose a bainitic steel alloy having a composition with constituents whose wt% ranges overlap those recited by the

claims. The Examiner further asserts that Hill et al. disclose making bainitic steel in substantially the same manner as claimed by the Applicants.

Applicants respectfully disagree with the Examiner's analysis. The steel of Hill et al. always contains 0.2 to 7% of Co, an element which is not present in Applicants' invention. Also, the steel of Hill et al. accepts contents of Cu, Ni, Mo and Nb which are much higher than in Applicants' invention. The steel of Hill et al. also accepts Ta and W, which are not present in Applicants' steel. This is clear from Applicants' claims, which recite the particular steel components, and that the remainder is iron and impurities resulting from preparation.

Further, the steel of Hill et al. contains almost no B, and never contains Ti, while these elements are compulsory in the invention, for the reasons discussed above regarding the necessary absence of ferrite. Thus, the composition of Hill et al. is even more remote from Applicants' invention than the other documents, discussed above.

Generally speaking, the steels of Hill et al. have a high strength, a high ductility and a high toughness, these last two qualities being not particularly required in the invention. The ultimate tensile strength (UTS) of the steels of Hill et al. is very high, nearly always much higher than 1300MPa (1 ksi = 6,89MPa), while Applicants' claimed invention requires an Rm (=UTS) between 1100 and 1300MPa.

The properties of Hill et al. can be obtained by two different processes.

1) Forming a 100 % martensitic structure by rapid quench, avoiding the bainitic field and the presence of residual austenite; then performing one or two aging treatments at 400-1000°F (204-537°C). The examples show that these aging treatments are, in fact, performed between 250-600°F (121-315°C), which is well under what Applicants' invention requires for the precipitation annealing (at least 425°C, or at least 500°C, according to the precise steel composition). In that case, bainite must be avoided: see column 3, lines 3-16, particularly line 16, column 2, lines 17-36, and column 3, lines 65-68.

2) Forming bainite after an austenization at 1400-1500°F (802-815°C) and possibly a hot working in this temperature range, by a very quick cooling, equivalent to a quench, possibly with a "cold-hot" working, down to a temperature situated in front of the bainite field, at which an isothermal treatment is then performed, as long as possible

for obtaining nearly only bainite, before coming back to ambient temperature, then performing a tempering treatment.

This process of Hill et al. differs from the process of the invention mainly in the following ways.

1. Applicants' invention first performs a hot forging at a high temperature 1100-1300°C, while in Hill et al. such a hot deformation is not compulsory; and if performed, it is made during a mere austenization at a relatively low temperature (802-815°C).

2. Applicants' invention then performs a slow cooling down to 600°C, then a controlled slow cooling between 600 and 300°C which brings the steel directly into the bainite field, avoiding the ferrite field, while Hill et al. perform a quick cooling, then an isothermal treatment which brings the steel into the bainite field; this isothermal treatment is absent in the invention.

3. Applicants' invention then performs a precipitation annealing at $\geq 425^{\circ}\text{C}$ or $\geq 500^{\circ}\text{C}$, while Hill et al. perform only a tempering at a relatively low temperature ($= 315^{\circ}\text{C}$) where a precipitation hardening is, anyway, not obtained.

These differences between the treatments unavoidably result in different structures and properties for both steels, in particular concerning toughness and tensile strength. See column 23, lines 1-39, column 22, lines 40-46, column 25, lines 7-10 (which is very explicit), and column 25, lines 27-30.

It is clear that the particular properties of Hill et al. result from the isothermal quench, which is not performed in Applicants' invention, where bainite is directly obtained by a slow and controlled cooling from a high temperature.

In fact the steels of Hill et al. are of the "maraging" type with high contents in Co (absent in the invention) and Ni (not compulsory in the invention and, if present, not higher than 4.5%). All steels according to the invention of Hill et al. described in the tables have a Ni content of at least 6.4%, that is well above the $\leq 4.5\%$ required by the invention, and also have a C content above the 0.25% maximum required by the present application.

For these reasons, the subject matter of claims 1, 5, 8-11 and 19 is clearly patentable over the cited reference.

The rejection of claims 1, 5, 8-11, 19 and 21 under 35 U.S.C. § 103(a) as being unpatentable over Nakamura et al. is respectfully traversed.

Concerning Applicants' previous arguments regarding Nakamura et al., the Examiner states that hot rolling and hot forging would be two variants of hot forming and therefore, their interchangeability would be obvious. Applicants' respectfully disagree.

A forging operation is performed on unitary parts, from a slug or a blank taken from a bar or a billet which has previously been cast and possibly already rolled for reducing its sectional area. The slug/blank is always heated before this forging at a high temperature and at a high speed, generally by inductive means, during at most some minutes. Then the slug/blank is treated by one, or at most two, forging tools which give it its final shape. In order limit the deterioration of the tools, the temperature of the slug/blank must be high. If not, the product is not shapable enough without large efforts.

A hot rolling operation is performed on a cast ingot or a continuously cast product of large dimensions. The product is first heated in a furnace, which is never an inductive furnace. Thus, the heating is much slower than before a forging and this long and slow heating leads to a grain size which is much higher than on a product ready for forging. And generally, the initial sectional area of the product is higher than for products intended to be forged. Several rolling passes are necessary, at least performed in two different rolling mills, each of them having several rolling stands. Most often, three rolling mills are used, i.e. a roughing mill (or breakdown mill), a tandem mill and a finishing mill.

Unavoidably, the structure obtained on the final product is different after a hot rolling and after a forging. In particular, for a hot rolling the temperature may be lower than for a forging, where a temperature over 1000°C is necessary for not greatly wearing the tools. On the contrary, for a hot rolling, 1100-1300°C (such as in the invention) would be too high, as this temperature would require too long a heating, with an exaggerated formation of scale on the surface of the product and too high an energy cost.

Another difference in the obtained structures is that a forged product is randomly fibered, while in a hot rolled product the fibers are parallel to the rolling direction.

Yet another difference is that after a hot rolling, the product is cooled on a device on which the cooling speed cannot be mastered. It would not be possible to obtain the

precise control of the cooling speed between 600 and 300°C which is required by the invention.

Additionally, according to the Examiner, the fact that the examples of steels according to the invention would have a Pcm higher than required by Nakamura et al. would be of no importance, since a limit on Pcm is not required by the invention.

Precisely, the fact that no range for the Pcm value is required by the invention shows that the steels of the invention are not required to have the same properties as the steels of Nakamura et al., in particular the good weldability which is obtained if Pcm is ≤ 0.28 in Nakamura et al.

Further, although B may be present in Nakamura et al. and Ti is always present, there is no obligation in Nakamura et al. for the following:

- 1) B = 5-50 ppm
- 2) Ti ≥ 3.5 N
- 3) 1) and 2) simultaneously.

These requirements are necessary for obtaining a purely bainite structure as required by Applicants' amended claim 1. No corresponding obligations are present in Nakamura et al., and none of the examples respect this requirement, because none of the examples contain B. In fact, no requirement for a purely bainite structure can be found in Nakamura et al.

Concerning the cooling speed after hot rolling, column 6, lines 39-58 of Nakamura et al. shows that it must be between 1 and 50°C/s. This is a very wide range, which can cover many types of cooling modes, including air cooling but also forced cooling with a different and more powerful medium than air, like water. The range $\leq 3^\circ\text{C/s}$ between 600 and 300°C of the invention:

1) overlaps only a very limited part of the 1-50°C/s range of Nakamura et al., and this limited part can only be obtained by air cooling;

2) means that a very precise control of the cooling rate in a very precise temperature range must be performed (see above for the reasons), while such a requirement is totally absent in Nakamura et al.

Also, note column 6, lines 59-6 where it is said that the controlled cooling must result in the formation of lower bainite or martensite, and to this end the controlled cooling must not end over 580°C. That implies that formation of martensite is at least

allowed and even wished in Nakamura et al., while it is completely excluded in the invention; and that the controlled and possibly fast cooling of Nakamura et al. must begin well over 600°C (namely already at the end of hot rolling), so possibly at about 950-1200°C and at least 760°C in the examples of table 3. This again goes against Applicants' invention, where the controlled cooling phase, always at a low speed $\leq 3^{\circ}\text{C/s}$, must extend between 600 and 300°C, so in a temperature range lower than required in Nakamura et al.

The kind of bainite which is allowed in Nakamura et al. is only lower bainite, that is formed at a temperature close to the martensite transformation temperature M_S (See document 1). Further, nowhere in Nakamura et al. is an indication that the structure would be bainite only. Additionally, in the examples of Nakamura et al., the samples of tables 1 and 3 have yield strengths of at most 833 MPa and tensile strengths at most of 860 MPa. On the contrary, Applicants' amended claim 1 requires a yield strength greater than 900 MPa and a tensile strength of 1000-1300 MPa. That clearly shows that Nakamura et al. and the invention are not identical on their essential features.

Applicants' provide the Examiner with the following supplementary example according to the invention.

SUPPLEMENTARY EXAMPLE

A steel having a composition $C = 0.155\%$; $Mn = 1.149\%$; $Si = 0.171\%$; $Ni = 0.148\%$; $Cr = 0.787\%$; $Mo = 0.098\%$; $V = 0.720\%$; $S = 0.025\%$; $P = 0.012\%$; $Cu = 0.288\%$; $Al = 0.017\%$; $Ti = 0.028\%$; $B = 0.0025\%$; $N = 0.0078\%$; (so : $Ti/N = 3.59$), the remaining being Fe and impurities, was hot-forged at 1280°C, then allowed to cool with a cooling speed of 0.8°C/s between 600 and 300°C, so as to obtain a 100% bainite structure. Then a precipitation annealing at 600°C during 2h was performed. $R_e = 1075$ MPa and $R_m: 1175$ MPa were obtained. This example represents the embodiment where the precipitation hardening is obtained by the addition of V only, like example 2 of the application as filed. But contrary to this example 2, it contains the Ti which is required by present claim 1, and in a quantity sufficient for obtaining $Ti/N > 3.5$.

For these reasons, the subject matter of claims 1, 5, 8-11 and 19 is clearly patentable over the cited reference.

The rejection of claims 1, 5, 8-11 and 19-21 under 35 U.S.C. § 103(a) as being unpatentable over JP '246 is respectfully traversed.

Concerning Applicants' previously asserted arguments regarding JP '246, the Examiner states that the prior art meets Applicants' claims, since the combination of V, Ni, Cu and Al can be found in the invention and JP '246. Further, the Examiner states that the temperature of the hot treatment of JP '246 could be 1100-1300°C, since it speaks only of the end temperature of the transformation for the beginning of the cooling operation, and thus the hot transformation can begin at a temperature some hundreds of degrees higher. The Examiner also asserts that the cooling speeds of JP '246 and the invention would overlap, and that in both cases a bainitic structure is obtained (lower bainite in JP '246). Lastly, the Examiner asserts that the mechanical properties would be identical in both cases, since the production processes would be similar.

The steels of JP '246 are intended for making molds for injection/extrusion of plastics, for which molds the requirements are:

1. A perfect surface aspect, which is not required in the steels of the invention.
2. A good toughness, which is not necessary in the invention.
3. A good ability to be formed at a low temperature: "crimp workability", for obtaining shapes like ondulations, folds, serrations. This has nothing to do with Applicants' invention, where the steels are not intended to undergo a low temperature deformation which would give them such a finely shaped structure.
4. A resistance to corrosion by plastics, which is not needed in the invention. This resistance to corrosion by plastics is obtained by the simultaneous presence of Cr and Mo in JP '246.

Concerning the composition, in JP '246 Mo is compulsory, while it is only optional in the invention. B is optional in JP '246, while it is compulsory in the invention; but if it is present in JP '246, it can reach higher contents (0.01%) than in the invention where it is strictly limited to 0.0005 – 0.004%. In JP '246, Ti is only optional, while it is compulsory in the invention, in addition to the requirement regarding Ti/N, which is not present in JP '246. If Ti is present in JP '246, it can reach much higher contents than in the invention (up to 0.6%). This shows that the motivations for adding Ti are not identical in both instances.

Also in JP '246, Ni, Cu and Al are always simultaneously present at high contents ($\text{Ni} \geq 1.50\%$, $\text{Cu} \geq 0.3\%$, $\text{Al} \geq 0.3\%$), which is confirmed by the examples of table 1. In Applicants' invention, this simultaneous presence is possible, but not compulsory.

None of examples A-H of JP '246 is in accordance with Applicants' invention. None contains B, some contain W, (which is not present in Applicants' steel), and Ti is either absent or present at far too high a content. Additionally, in the examples A-F according to the invention described by JP '246, a very low content in O is present for obtaining a mirror finish. Such a requirement is not present in Applicants' invention, where O may only be present at a usual impurity level, that is some or several tens of ppm (depending on the precise steelmaking process and on the contents in oxide-forming elements like Al, Ti, Si). This is evident by Applicants' claim language which recites the particular components, with the remainder being iron and impurities resulting from preparation.

These differences show that, though there can be some overlapping between the compositions of JP '246 and the claimed invention, the requirements concerning the precise steel properties induced by these compositions are different, as shown by the differences between the examples of JP '246 and the invention. These distinctions are not unexpected, since JP '246 concerns steels for making molds for plastic parts and not forged parts, as in Applicants' invention. Additionally, the compositions of JP '246 would not give an obvious starting point to a person skilled in the art for solving the problems at the basis of the invention.

Applicants' claimed invention is a combination of a composition (with several possible variants) and of a treatment process (which must be adapted to the chosen compositional variant), as recited in claim 1.

The process of JP '246 is completely different from the one of the invention. After the hot working step of JP '246, a cooling rate $\geq 0.5^\circ\text{C/s}$ is required under 900°C , down to the lower bainite field ($< 400^\circ\text{C}$) where the product must be kept during 0.5h, while in the invention, the bainite field must be crossed by the forged product between 600 and 300°C at a low cooling speed, but without any isothermal step.

Unavoidably, the microstructures and properties obtained are different, for the following reasons.

1. In JP '246 a forging is not performed as in the invention as now claimed, but only a vaguely cited hot-working step.

2. The requirements for the cooling rate after hot working are different in JP '246 and in the invention.

3. There is no isothermal treatment in the invention, where lower bainite is not limitatively sought, while the isothermal treatment of JP '246 aims at obtaining lower bainite, and not another type of bainite.

4. The possible absences of B and Ti in JP '246 do not guarantee that before reaching the lower bainite field, the steel of JP '246 would not cross the ferrite field, which would lead to the presence of residual ferrite in the final structure. This is excluded in Applicants' claimed invention, though the bainite field is always reached by its upper region. Thus, the joint presences of B and Ti, and $Ti/N \geq 3.5$ is necessary in combination with the other requirements of claim 1 to achieve Applicants' claimed invention.

Further, in table 2 of JP '246, only lower bainite is required. Samples 11-14 which contain only upper bainite are excluded from the invention of JP '246, This is yet another reason why JP '246 would not provide a credible starting point for one of ordinary skill in the art to achieve Applicants' invention.

Additionally, the yield strength of the steels of JP '246 is never given, while Applicants' amended claim 1 requires a particular yield strength.

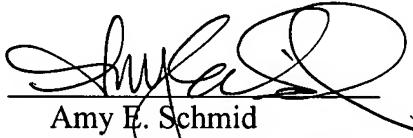
For these reasons, the subject matter of claims 1, 5, 8-11 and 19 is clearly patentable over the cited reference.

Therefore, in view of the foregoing amendments and remarks, it is submitted that each of the grounds of rejection set forth by the Examiner has been overcome, and that the application is in condition for allowance. Such allowance is solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

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